

R&D on Low-mass & Light GEM for EIC Forward tracker

Preliminary results on copper-less GEM

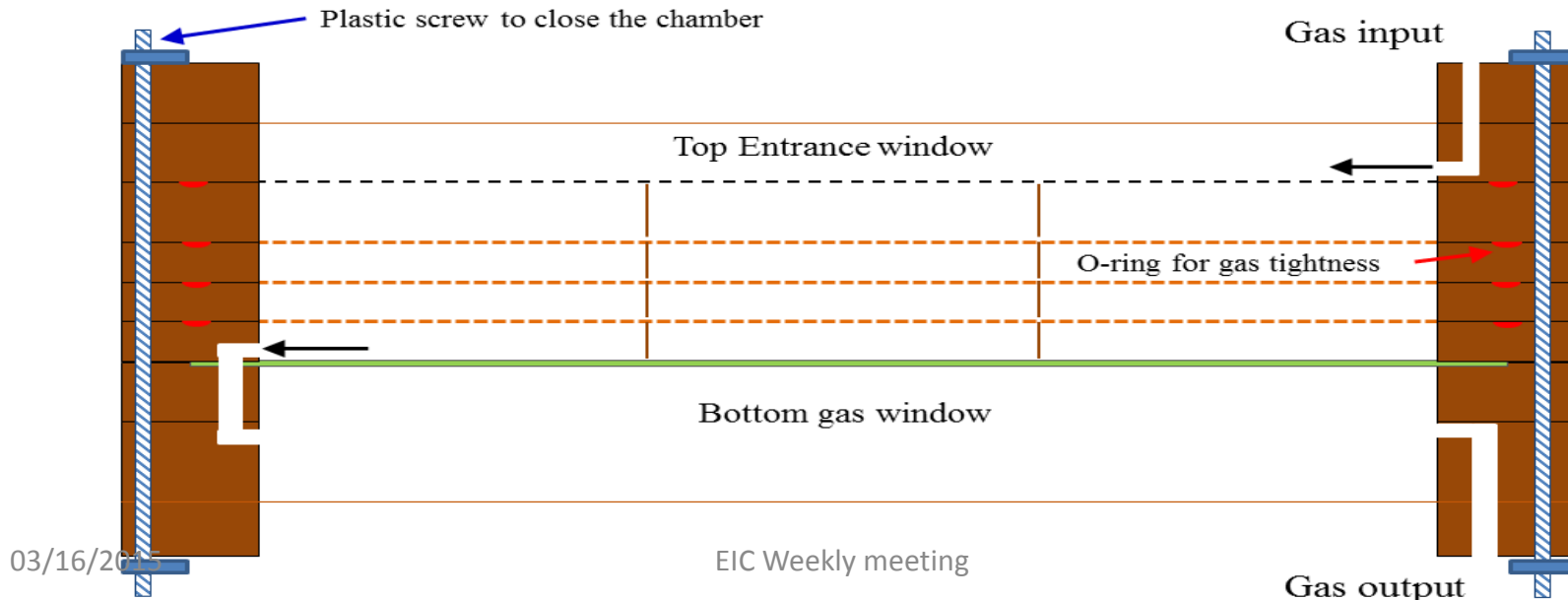
Kondo Gnanvo

EIC Weekly meeting, 03/16/2015

Low mass GEM for EIC Forward tracker: Honeycomb-less triple-GEM

- R&D @ UVa for EIC Forward Tracker is focus on light and low mass triple GEM
 - COMPASS-like Honey comb support replaced by top and bottom gas window
 - SBS Tracker GEMs already with top gas window in place of honey comb and STAR FGT @ BNL has both top and bottom window
- 2D strips readout board also based on same copper clad Kapton material used for GEM foils
- Material budget in an EIC GEM chamber equally dominated by the **Kapton** and **copper** material
- One step further is to remove the Copper from the equation and this is what the Copperless GEM is about

Light & low mass EIC GEM prototype II



Low mass GEM for EIC: Material budget of honeycomb-less triple-GEM

SBS Back Tracker with standard GEM foil

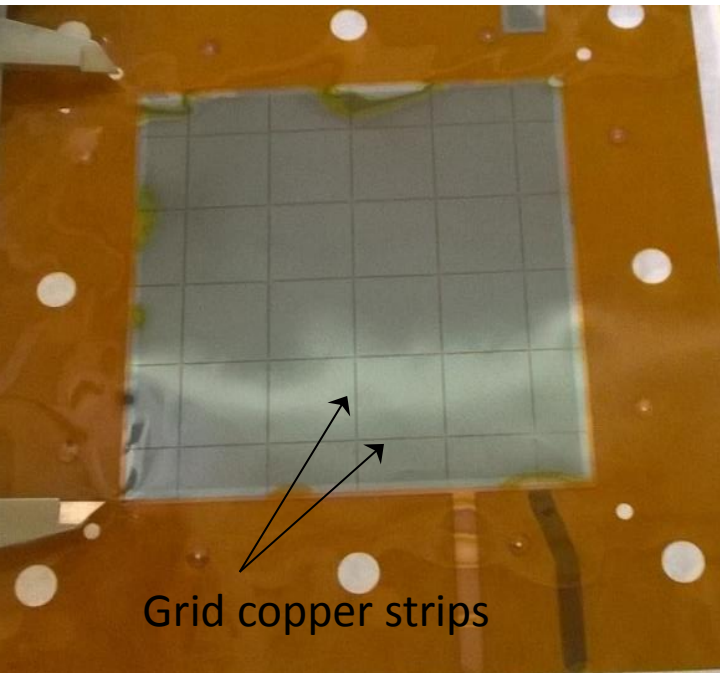
	Quantity	Thickness μm	Density g/cm^3	X0 mm	Area Fraction	X0 %	S-Density g/cm^2
Window							
Mylar Drift	1	10	1.39	287	1	0.0035	0.0014
Copper	1	5	8.96	14.3	1	0.0350	0.0045
Kapton	1	50	1.42	286	1	0.0175	0.0071
GEM Foil							
Copper	6	5	8.96	14.3	0.8	0.1678	0.0215
Kapton	3	50	1.42	286	0.8	0.0420	0.0170
Grid Spacer							
G10	3	2000	1.7	194	0.008	0.0247	0.0082
Readout							
Copper-80	1	5	8.96	14.3	0.2	0.0070	0.0009
Copper-350	1	5	8.96	14.3	0.75	0.0262	0.0034
Kapton	1	30	1.42	286	0.2	0.0021	0.0009
G10	1	120	1.7	194	1	0.0619	0.0204
NoFlu glue	1	60	1.5	200	1	0.0300	0.0090
Honeycomb							
Nomex	1	6000	1	13125	1	0.0457	0.6000
G10	2	120	1.7	194	1	0.1237	0.0408
Gas							
(CO2)	1	9000	1.84E-03	18310	1	0.0492	0.0017
					Total	0.636	0.737

EIC Forward Tracker with standard GEM foil

	Quantity	Thickness μm	Density g/cm^3	X0 mm	Area Fraction	X0 %	S-Density g/cm^2
Window							
Kapton Drift	2	25	1.42	286	1	0.0175	0.0071
Copper	1	5	8.96	14.3	1	0.0350	0.0045
Kapton	1	50	1.42	286	1	0.0175	0.0071
GEM Foil							
Copper	6	5	8.96	14.3	0.8	0.1678	0.0215
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Kapton	1	50	1.42	286	0.2	0.0035	0.0014
Kapton	1	50	1.42	286	1	0.0175	0.0071
NoFlu glue	1	60	1.5	200	1	0.0300	0.0090
Gas							
(CO2)	1	15000	1.84E-03	18310	1	0.0819	0.0028
					Total	0.471	0.090

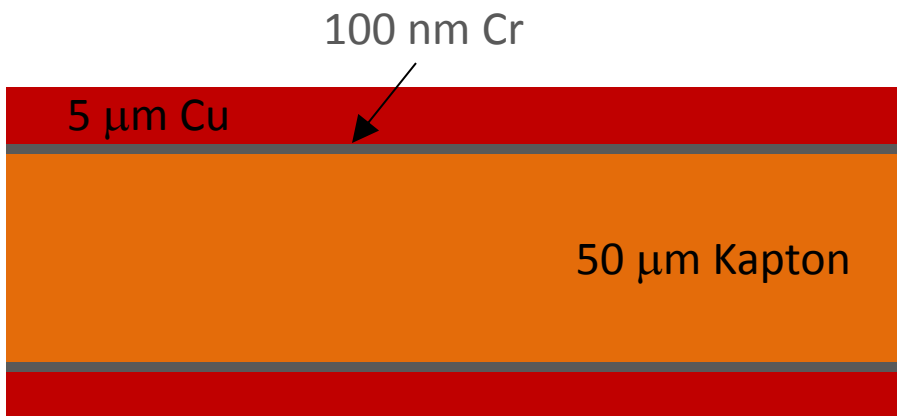
About 25 % reduction of the material budget when honeycomb support is removed

Low mass GEM for EIC: copper-less (Cu-less) triple-GEM

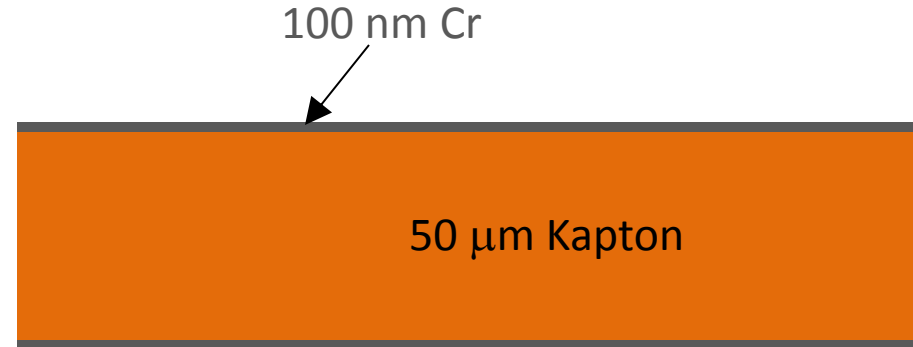


Cu-less GEM foil

- Standard GEM foil with the copper layer completely removed
- Copper clad Kapton based material comes with 100 nm Chromium (Cr) layer between Copper and Kapton
- 100 nm Cr layer replace the 5 μm Copper as top and bottom GEM electrode
- Cu-less GEM Samples from Rui with a grid of copper strips
 - Ensure electrical contact but expected to be removed in the future



Standard GEM



Cu-less GEM

Low mass GEM for EIC: material budget of Cu-less triple-GEM

EIC Forward Tracker with **standard** GEM foil

	Quantity	Thickness μm	Density g/cm^3	X0 mm	Area Fraction	X0 %	S-Density g/cm^2
Window							
Kapton Drift	2	25	1.42	286	1	0.0175	0.0071
Copper	1	5	8.96	14.3	1	0.0350	0.0045
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Copper	6	5	8.96	14.3	0.8	0.1678	0.0215
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Grid Spacer							
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Copper-80	1	5	8.96	14.3	0.2	0.0070	0.0009
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Kapton	1	50	1.42	286	1	0.0175	0.0071
NoFlu glue	1	60	1.5	200	1	0.0300	0.0090
Gas							
(CO2)	1	15000	1.84E-03	18310	1	0.0819	0.0028
Total						0.471	0.090

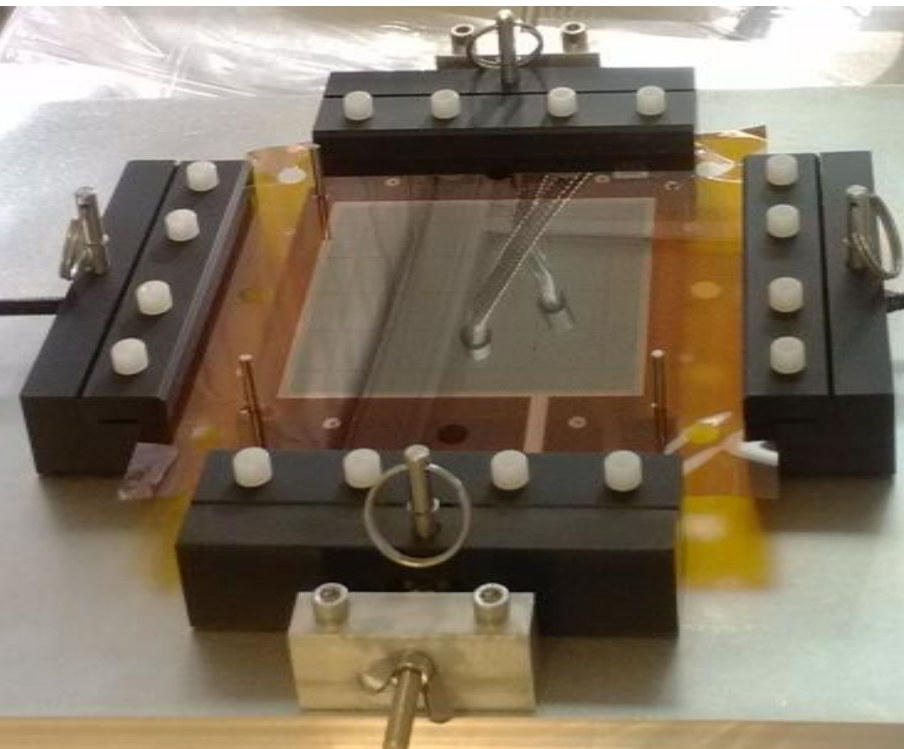
EIC Forward Tracker with **Copperless** GEM

	Quantity	Thickness μm	Density g/cm^3	X0 mm	Area Fraction	X0 %	S-Density g/cm^2
Window							
Kapton Drift	2	25	1.42	286	1	0.0175	0.0071
Copper	1	0	8.96	14.3	1	0.0000	0.0000
Kapton	1	50	1.42	286	1	0.0175	0.0071
GEM Foil							
Copper	6	0	8.96	14.3	0.8	0.0000	0.0000
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Kapton	1	50	1.42	286	0.2	0.0035	0.0014
Kapton	1	50	1.42	286	1	0.0175	0.0071
NoFlu glue	1	60	1.5	200	1	0.0300	0.0090
Gas							
(CO2)	1	15000	1.84E-03	18310	1	0.0819	0.0028
Total						0.235	0.060

About 50% reduction in the material in a EIC-like chamber with Copperless GEM

The contribution of the chromium layer has not been added but should be very small so we can neglect it to the first order

10 × 10 cm² Cu-less triple GEM prototype



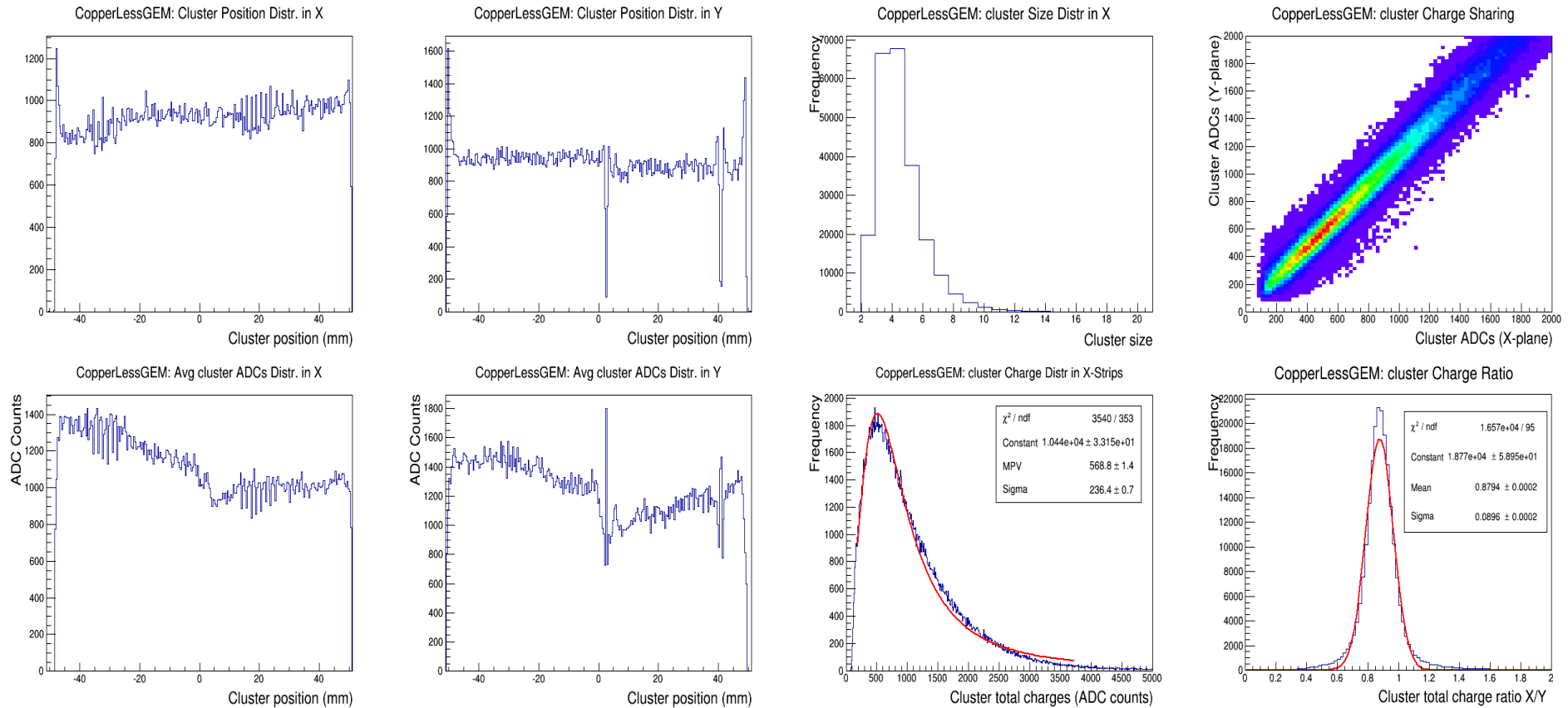
Preliminary test with cosmics

- Cu-less GEM prototype in cosmic test for 5 days
- 4.1 kV with standard HV divider and Ar/CO₂ (70/30)
- 250 K events collected for the analysis

Assembly of the prototype

- Got three 10 × 10 cm² Cu-less foils from Rui
- Cu-less triple-GEM with existing COMPASS readout (with copper...) and gas box
- HV test of the foils → excellent behavior
- Dedicated mechanical stretcher for small GEM foils

Preliminary results with cosmos



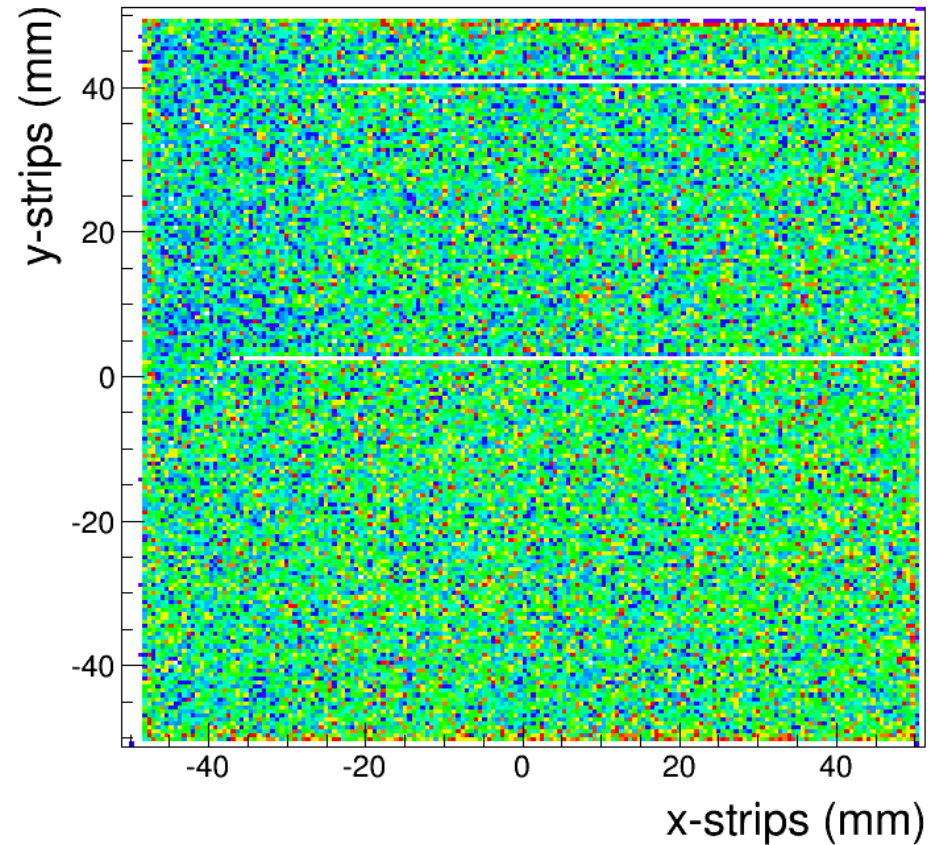
General characterization of the performances of the detector under cosmic

Good uniformity response and gain uniformity

Preliminary results with cosmics



CopperLessGEM: Hit Position Map



Good 2D hit distribution

Don't see the copper strip grid pattern (but maybe require more statistics)

Zero efficiency lines likely from broken readout strips

Conclusion

- Preliminary results from cosmic tests of the first Cu-less triple-GEM prototype show very good and expected performances of the chamber
- Need to study the spark rate and Cu-less GEM foil resilience under high rate and highly ionizing particle condition and perform some standard characterization
- High rate and long term performance study will be done with our x-ray box
- Start discussion with Rui for large size Cu-less GEM foil production → Could assemble one EIC-FT GEM prototype II with Cu-less GEM
- Study the feasibility of Cu-less COMPASS-like readout board (with Cartesian / uv-strips)
- This can be a very exciting development for future GEM trackers projects